# Source Identification of a Continuous Dry Weather Stormwater Collection System Discharge

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# Report Documentation Page

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# Background

- Malmstrom Air Force Base (MAFB) is located in Great Falls, MT
- Significant amount of dry weather flow present in the storm sewer collection system
- Continuous flow discharges to Whitmore Ravine eventually reaching the Missouri River

# Issues

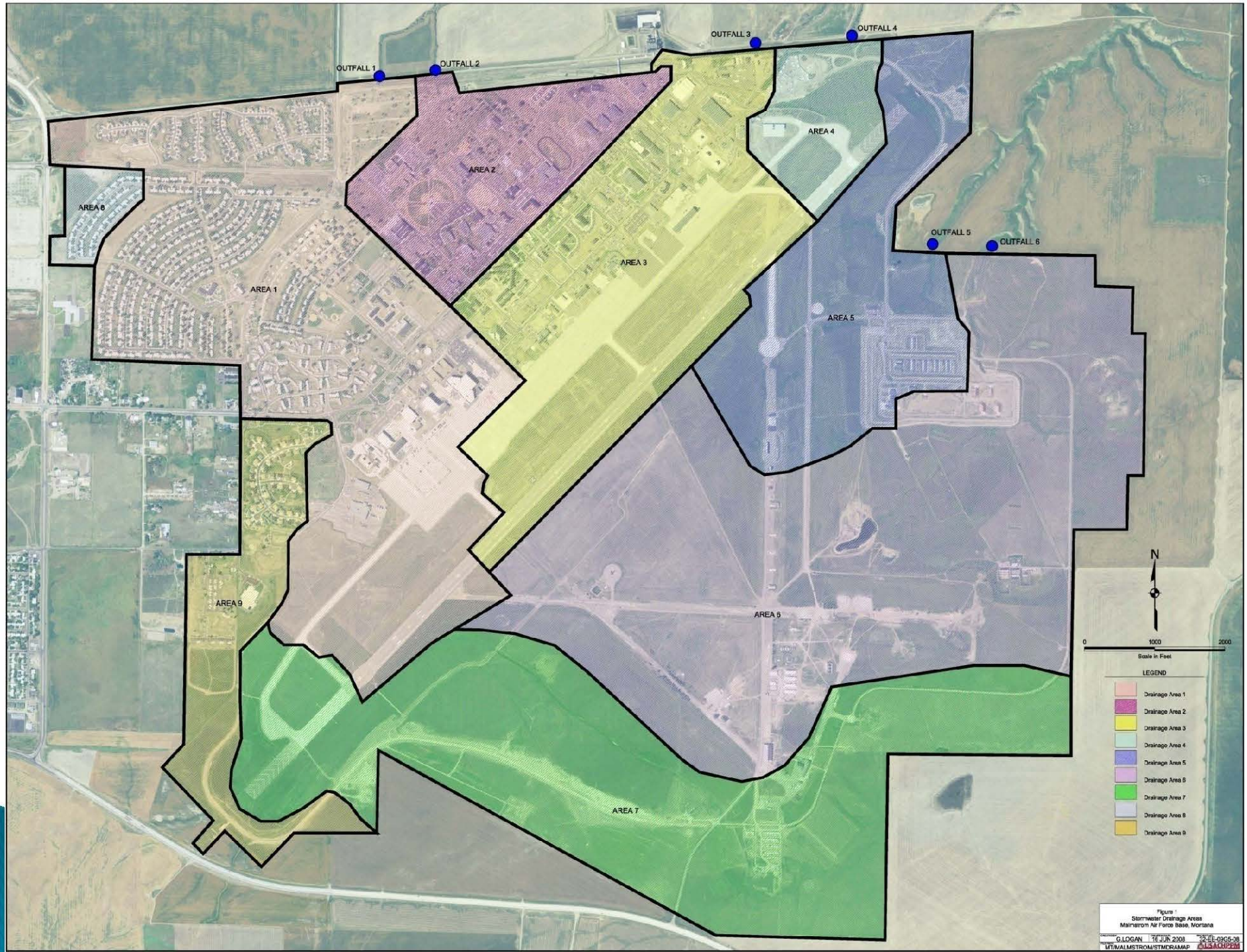
- The constant high flow of water has caused considerable erosion in Whitmore Ravine
- The erosion has led to:
  - Increased deposition in the Missouri River
  - Public protest over damage to private farm land and the adjoining state managed easement
  - Congressional concern over the DoD impact to the watershed

# Project Goals

- Determine the source(s) of the continuous dry weather flow
- Quantify the flow
- Evaluate alternatives for managing the flow

# Stormwater Collection System

- Majority of the system built in the 1950's
- Traditional concrete piping throughout the main part of the installation
- Flight line constructed using a combination of concrete piping and drain tile
- Nine drainage areas on the installation


OUTFALL 1
OUTFALL 2
OUTFALL 3
OUTFALL 4
OUTFALL 5
OUTFALL 6
AREA 1
AREA 2
AREA 3
AREA 4
AREA 5
AREA 6
AREA 7
AREA 8
AREA 9
N
0
1000
2000
Scale in Feet
LEGEND
Drainage Area 1
Drainage Area 2
Drainage Area 3
Drainage Area 4
Drainage Area 5
Drainage Area 6
Drainage Area 7
Drainage Area 8
Drainage Area 9
Figure 1
Stormwater Drainage Areas
Malmstrom Air Force Base, Montana
G.LOGAN
16 JUN 2008
32-EE-03C5-08
MT/MALMSTROM/STMDRAMAP
USACHPPM

# Approach

- In-situ flow analysis at key sections of the MAFB collection system during dry weather
- Monitoring points (MPs) were set up at the three outfalls experiencing dry weather flow
- The dry weather flow at each outfall was followed upstream and additional MPs were established

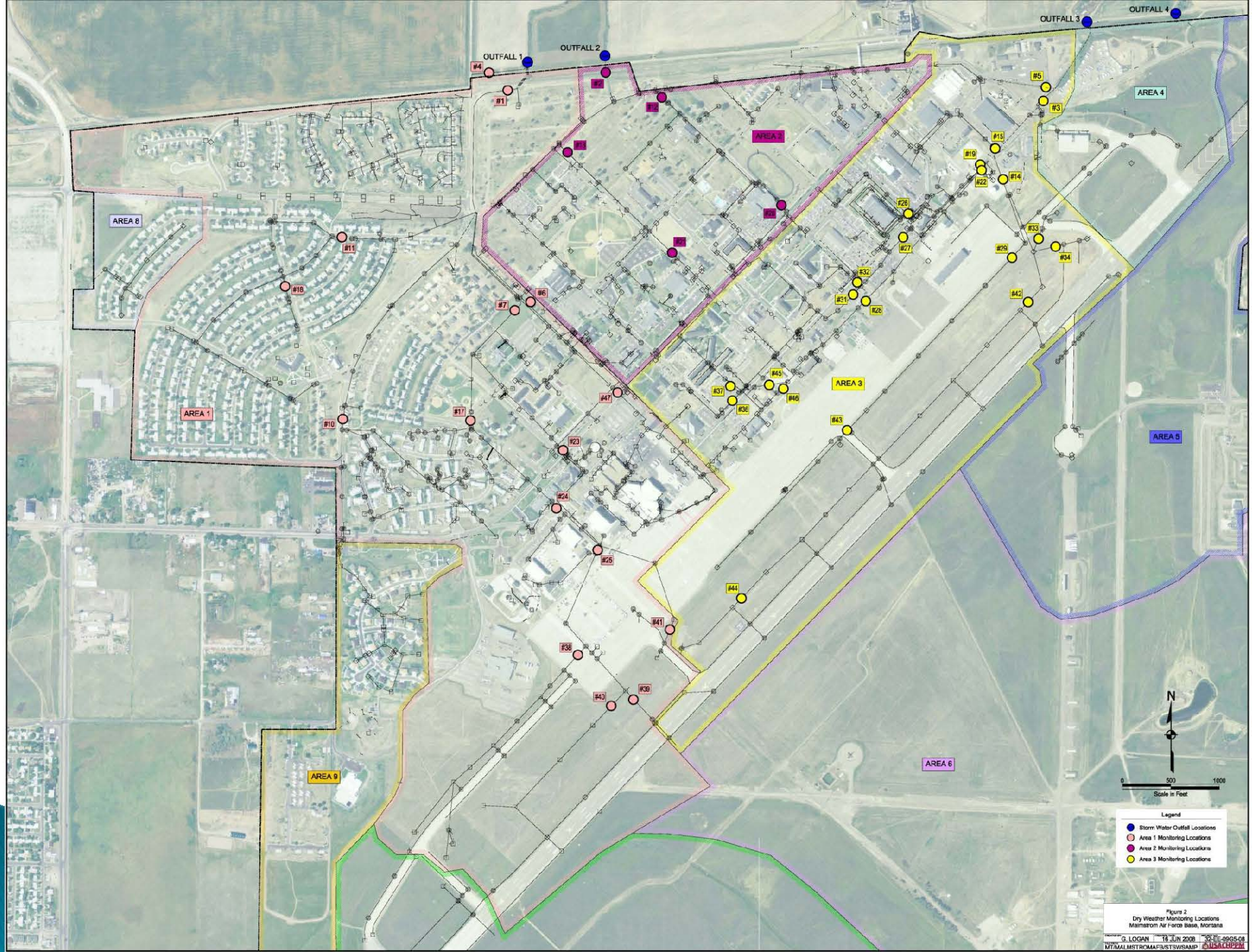



Figure 2
Dry Weather Monitoring Locations
Malmstrom Air Force Base, Montana

G. LOGAN | 16 JUN 2008 | 32-EE-0965-08
MT/MALMSTROMAFB/STSWSAMP | USACHPPM

# Whitmore Ravine

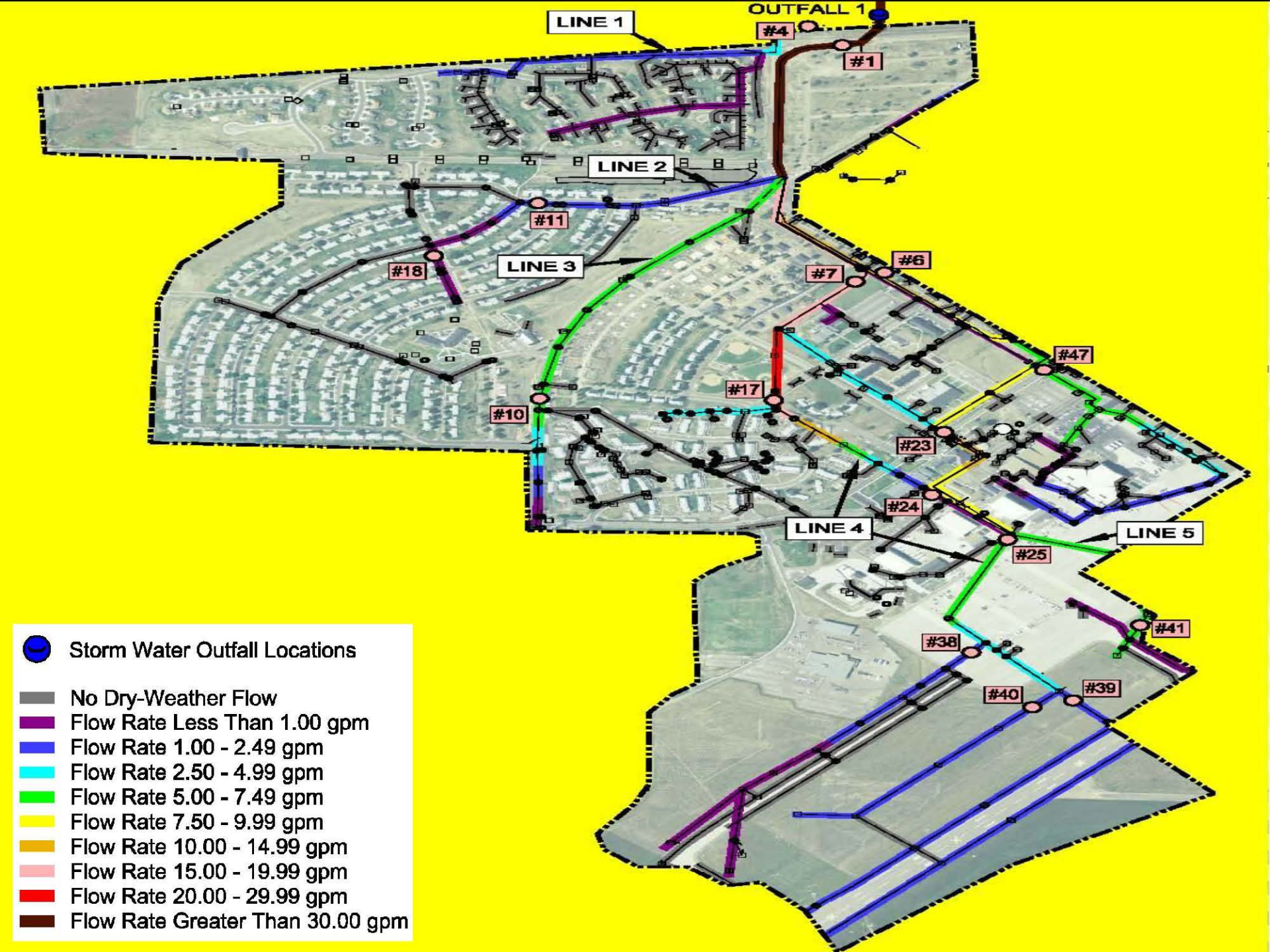
- MPs were also established in Whitmore Ravine
- To determine if any additional flow was contributing to the final discharge at the Missouri River
- Continuous monitoring of these discharges was not possible
- Instantaneous flow monitoring was performed daily

# Analytical Sampling

- Used to compare dry weather flow with potential water sources to determine origin
- Grab samples from potable water and ground water were used for comparison
- Conductivity, pH and cation/anion analysis were performed

# Results – Outfall 1

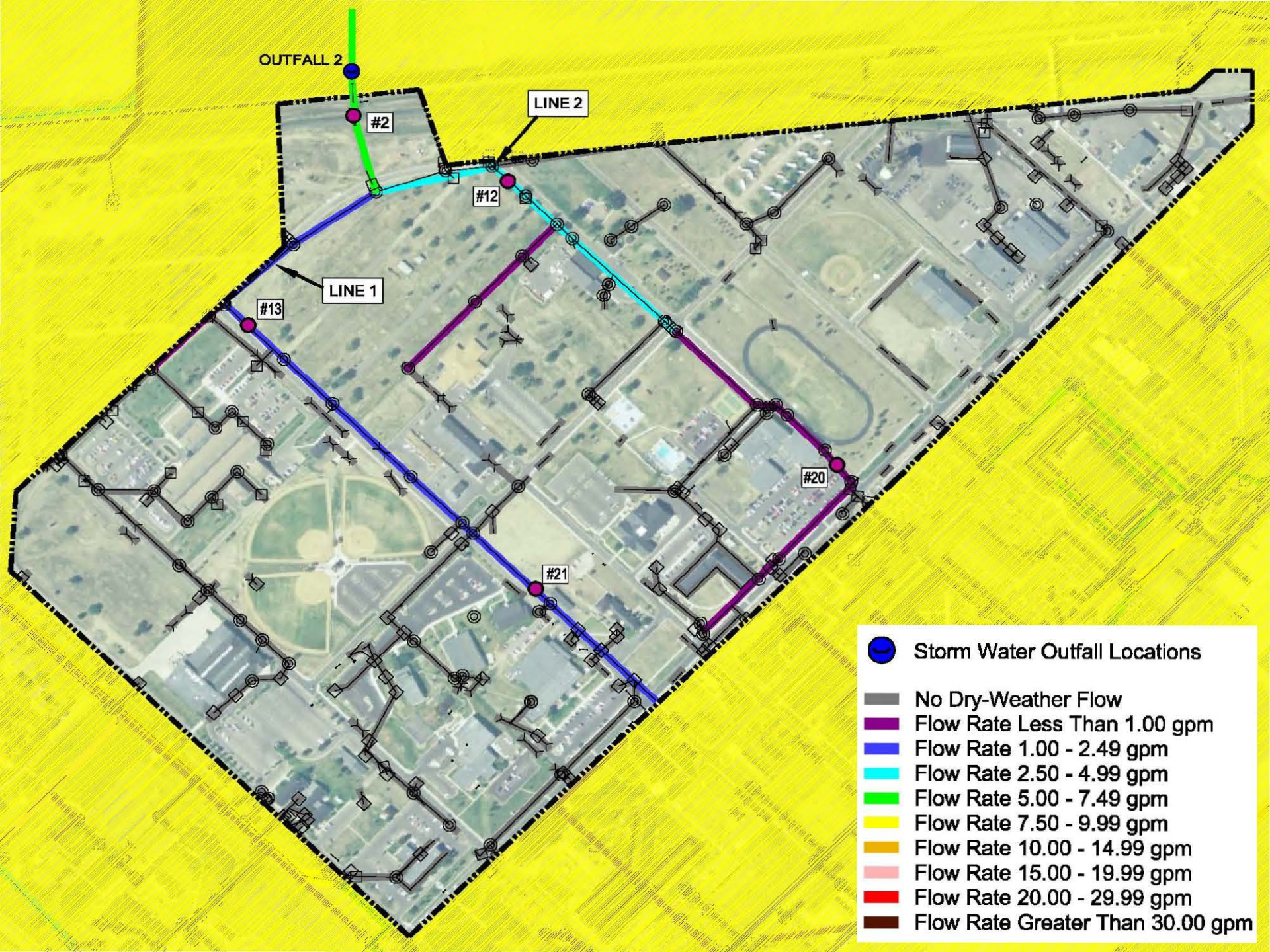
- Encompasses all housing areas, western portion of base operations and southwestern tip of flight line
- Discharge ~ 44 gpm
- 51% of total dry weather flow


LINE 1
OUTFALL 1
#4
#1
LINE 2
#11
#18
LINE 3
#7
#6
#47
#17
#10
#23
#24
LINE 4
LINE 5
#25
#41
#38
#40
#39
Storm Water Outfall Locations
No Dry-Weather Flow
Flow Rate Less Than 1.00 gpm
Flow Rate 1.00 - 2.49 gpm
Flow Rate 2.50 - 4.99 gpm
Flow Rate 5.00 - 7.49 gpm
Flow Rate 7.50 - 9.99 gpm
Flow Rate 10.00 - 14.99 gpm
Flow Rate 15.00 - 19.99 gpm
Flow Rate 20.00 - 29.99 gpm
Flow Rate Greater Than 30.00 gpm

# Groundwater Infiltration

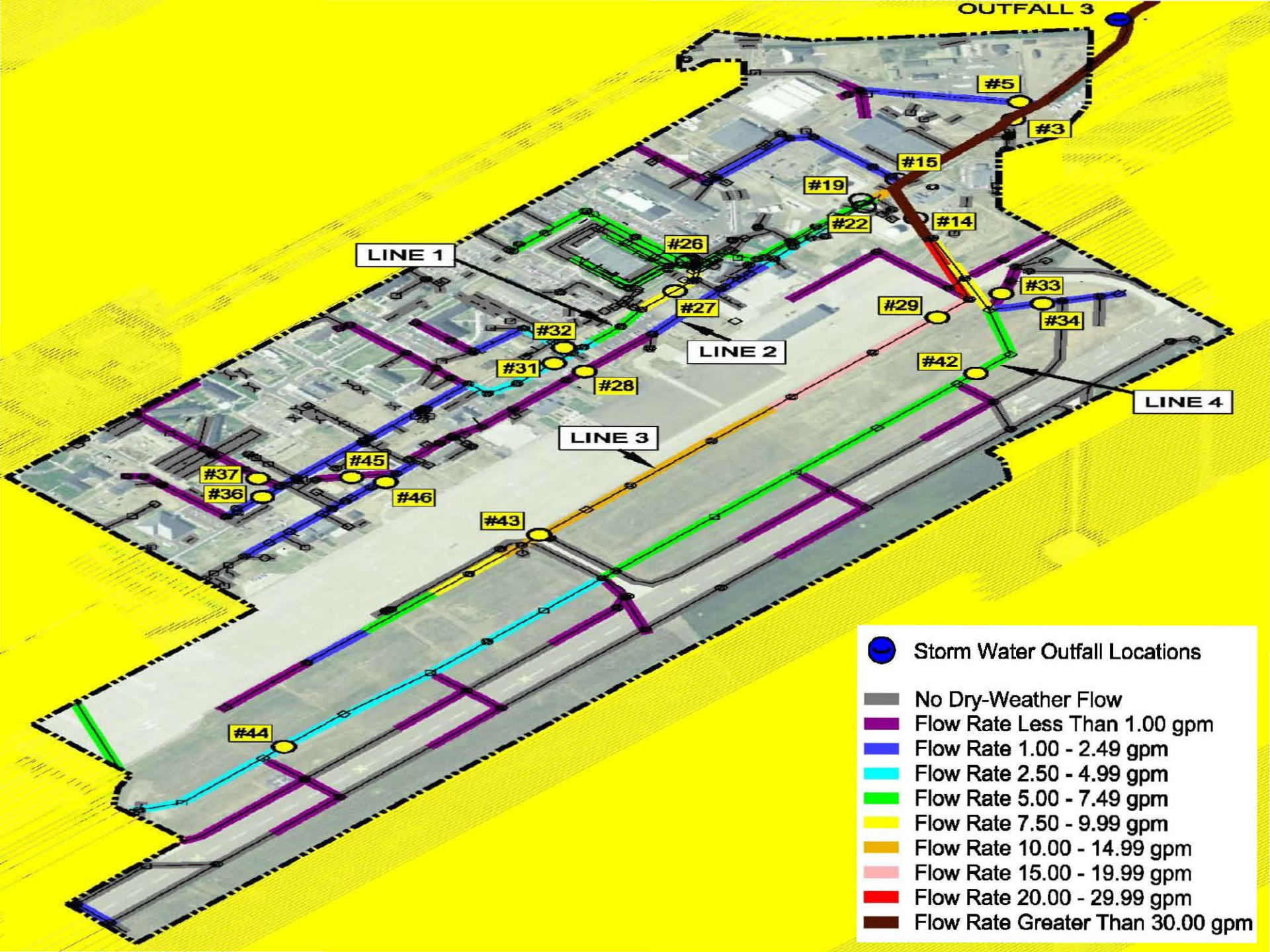
# Results – Outfall 2

- Encompasses the central portion of base operations
- Discharge ~ 6 gpm
- 7% of total dry weather flow


OUTFALL 2
#2
LINE 2
#12
LINE 1
#13
#20
#21
Storm Water Outfall Locations
No Dry-Weather Flow
Flow Rate Less Than 1.00 gpm
Flow Rate 1.00 - 2.49 gpm
Flow Rate 2.50 - 4.99 gpm
Flow Rate 5.00 - 7.49 gpm
Flow Rate 7.50 - 9.99 gpm
Flow Rate 10.00 - 14.99 gpm
Flow Rate 15.00 - 19.99 gpm
Flow Rate 20.00 - 29.99 gpm
Flow Rate Greater Than 30.00 gpm

# Results – Outfall 3

- Encompasses the northeast portion of base operations and almost the entire flight line
- Discharge ~ 36 gpm
- 42% of the total dry weather flow


OUTFALL 3
#5
#3
#15
#19
#22
#14
#26
LINE 1
#33
#29
#34
#27
LINE 2
#32
#31
#28
#42
LINE 4
LINE 3
#45
#37
#36
#46
#43
#44
Storm Water Outfall Locations
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Flow Rate Less Than 1.00 gpm
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Flow Rate 10.00 - 14.99 gpm
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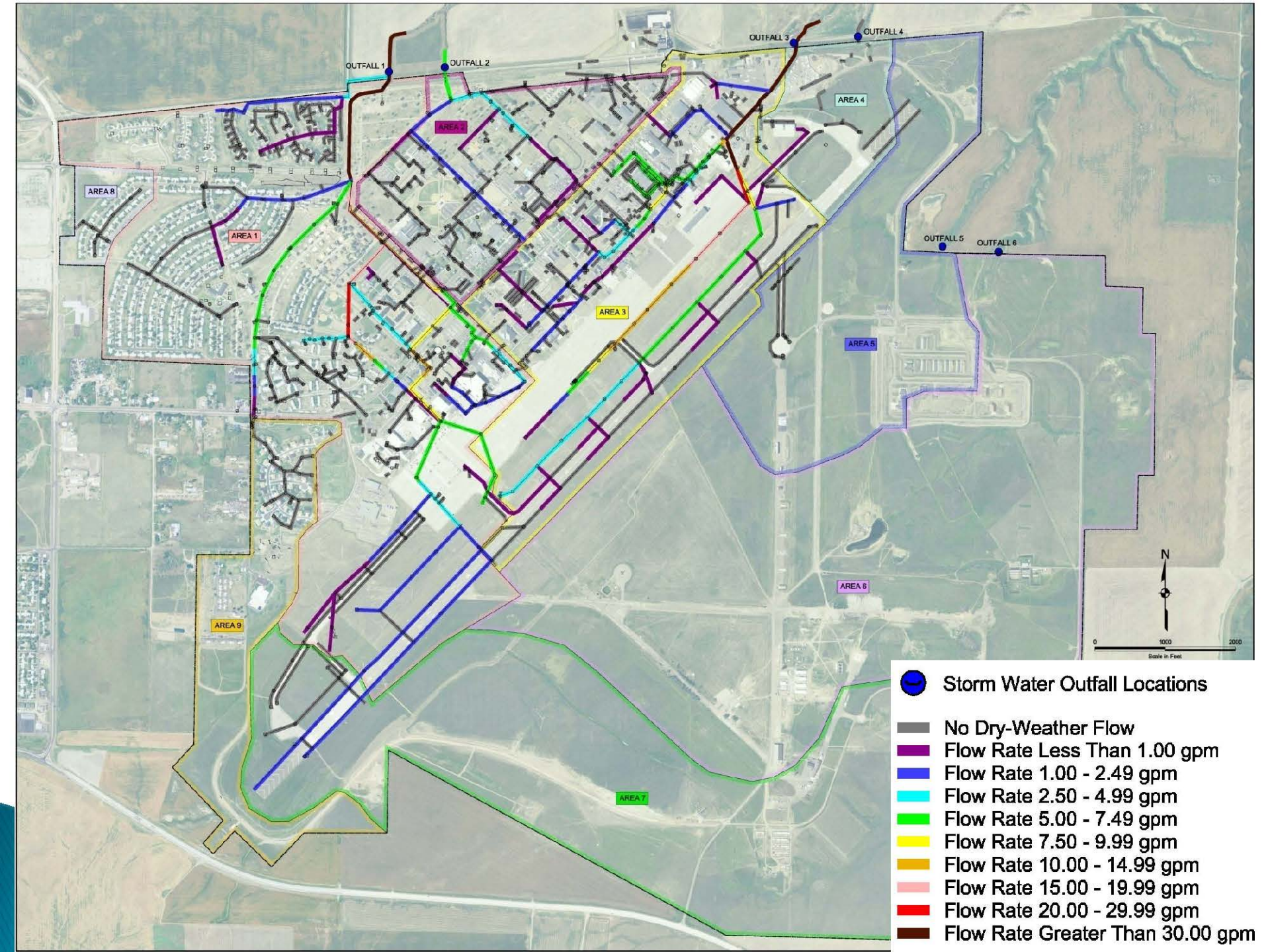
OUTFALL 1
OUTFALL 2
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OUTFALL 4
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Flow Rate 7.50 - 9.99 gpm
Flow Rate 10.00 - 14.99 gpm
Flow Rate 15.00 - 19.99 gpm
Flow Rate 20.00 - 29.99 gpm
Flow Rate Greater Than 30.00 gpm

# Results – Whitmore Ravine

| Date | Flow Rates (gpm) | | | | | |
|---|---|---|---|---|---|---|
| | East Fork (MP 8) | Outfall 3 | % From MAFB | West and Middle Forks (MP 9) | Outfalls 1 + 2 | % From MAFB |
| 16 Apr 08 | 43.0 | 27.1 | 63% | 19.9 | 13.9 | 70% |
| 17 Apr 08 | 35.5 | 27.6 | 78% | 23.3 | 15.6 | 67% |
| 15 May 08 | 57.4 | 33.9 | 59% | 63.4 | 54.9 | 87% |
| 16 May 08 | 35.5 | 27.1 | 76% | 35.8 | 47.9 | 100% |
| 17 May 08 | 19.7 | 25.2 | 100% | 34.8 | 47.2 | 100% |
| 18 May 08 | 26.1 | 27.6 | 100% | 50.2 | 39.8 | 79% |
| 19 May 08 | 19.7 | 23.3 | 100% | 41.1 | 23.9 | 58% |
| Average | 33.8 | 27.4 | 81% | 38.4 | 34.7 | 90% |

# Analytical Results

| | Bicarbonate Alkalinity (mg/L as $CaCO_3$) | Total Alkalinity (mg/L as $CaCO_3$) | Sulfate (mg/L) | Chloride (mg/L) | Calcium (mg/L) | Magnesium (mg/L) | Potassium (mg/L) | Sodium (mg/L) |
|---|---|---|---|---|---|---|---|---|
| Dry Weather Flow | 300 | 300 | 407 | 60.9 | 140 | 79 | 9.3 | 66 |
| Potable Water | 120 | 120 | 57.3 | 13.8 | 39 | 11 | 3 | 16 |
| Ground Water | 360 | 360 | 1460 | 53.5 | 390 | 260 | 36 | 290 |

| | pH | Conductivity (mS/cm) | TDS (mg/L) |
|---|---|---|---|
| Dry Weather Flow | 6.70 | 1.34 | 1000 |
| Potable Water | 6.60 | 0.35 | 220 |
| Ground Water | 6.55 | 3.71 | 2620 |

# Summary

- Groundwater infiltration seems to be the main cause of the dry weather flow
- Two points of entry:
  - Joints of manholes collars and around piping
  - Drain tiles around the flight line

# Alternatives Evaluation

- Reuse of dry weather flow for non potable water users
  - On-site irrigation
  - Vehicle washing
  - Non-contact cooling water
- Repair/Replacement of Stormwater Collection System
  - Disconnection/Replacement of stormwater lines
  - Lining the stormwater collection system

# Alternatives Evaluation Cont'd

- On-site irrigation
  - Water purchased from City of Great Falls ($1,630 per MGD)

| Month | Total Water Consumption (MGD) | Volume used for Irrigation (MGD) | Cost of Irrigation ($) |
|---|---|---|---|
| October | 15.0 | 3.0 | 4,890 |
| November | 11.2 | 0 | 0 |
| December | 13.6 | 0 | 0 |
| January | 13.1 | 0 | 0 |
| February | 11.6 | 0 | 0 |
| March | 10.4 | 0 | 0 |
| April | 11.8 | 0 | 0 |
| May | 17.7 | 5.7 | 9,291 |
| June | 21.1 | 9.1 | 14,833 |
| July | 43.2 | 31.2 | 50,856 |
| August | 59.1 | 47.1 | 76,773 |
| September | 34.5 | 22.5 | 36,675 |
| Total | 262.3 | 118.6 | 193,318 |

# Alternatives Evaluation Cont'd

- Reuse for vehicle washing
  - Water management pond would be necessary
  - Construction of a wash rack near the pond
  - Piping to car washes

- Reuse for non-contact cooling water
  - Central Heat Plant at MAFB is designed to fire natural gas and/or coal
  - Operates October through May
  - When in operation uses ~70 gpm (100 KGal/day)

# Alternatives Evaluation Cont'd

- Disconnection/Replacement of stormwater lines on the flight line
  - Could significantly decrease dry weather flow to outfalls 1 and 3
  - Would not remove all dry weather flow from collection system
- Lining stormwater collection system
  - Should reduce groundwater infiltration
  - Expensive

# Conclusions/Recommendations

- No obvious solution for eliminating flow to Whitmore Ravine
- Reuse, repair and replacement alternatives will all require significant infrastructure changes and/or additions = expensive
- Best option for elimination dry weather flow:

  Non potable water reuse
  - On-site irrigation in summer
  - Non-contact cooling water in the winter

# Questions?


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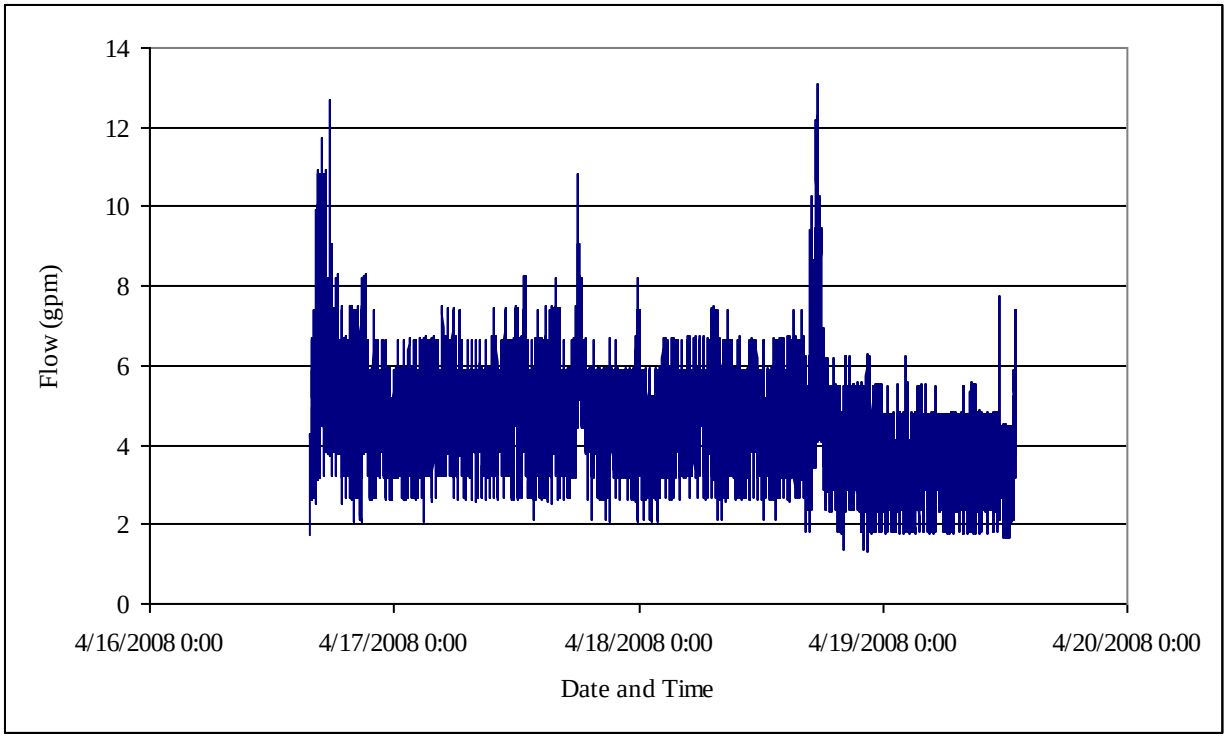
# Data Example




| | | |
|---|---|---|
| 4/16/2008 | 34% of the day | |
| | Total Flow (gal) | 2690.04 |
| | Average Flow (gpm) | 5.46 |
| | Minimum Flow (gpm) | 1.73 |
| | Maximum Flow (gpm) | 12.70 |
| 4/17/2008 | 100% of the day | |
| | Total Flow (gal) | 7096.80 |
| | Average Flow (gpm) | 4.93 |
| | Minimum Flow (gpm) | 2.13 |
| | Maximum Flow (gpm) | 10.83 |
| 4/18/2008 | 100% of the day | |
| | Total Flow (gal) | 6730.20 |
| | Average Flow (gpm) | 4.67 |
| | Minimum Flow (gpm) | 1.37 |
| | Maximum Flow (gpm) | 13.09 |
| 4/19/2008 | 50% of the day | |
| | Total Flow (gal) | 2838.42 |
| | Average Flow (gpm) | 3.63 |
| | Minimum Flow (gpm) | 1.64 |
| | Maximum Flow (gpm) | 7.75 |

# Hydrogeology

- MAFB sits atop a “bowl” filled with glacial till consisting of clay, sand and silt with gravel
- Overlying the till is a layer of glacial lake deposit composed of loose, easily erodible sand silt interspersed with clay
  - Can extend from surface to 50 ft deep
  - Contains a underlying layer of clay that may inhibit water from soaking further into the ground
- Water sits in this “bowl” and can be found very close to the surface